Overview of Geographic Information Systems

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PURPOSE

The purpose of this presentation is to make the TRANSIMS team members aware of the nature and capabilities of geographic information systems (GISs).

INTRODUCTION

- Geographic information systems are used by the U.S. Department of Transportation, Municipal Planning Offices, and various transportation research organizations in their work on transportation systems.

- A GIS provides a framework for accessing, manipulating, and analyzing geographic data.

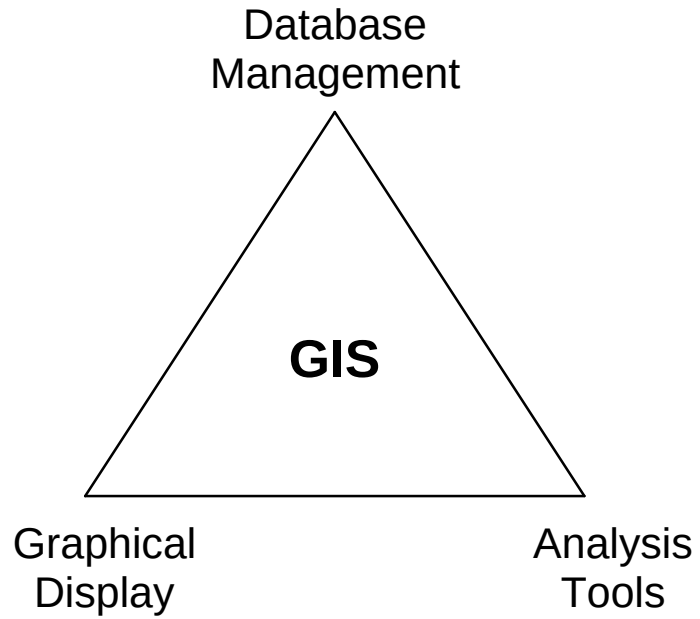
- GIS probably will have some role to play in TRANSIMS, but it is not yet clear what that role will be.

GIS USAGE IN TRANSPORTATION

- A 1990 survey of MPOs by the University of North Carolina found that
  - 34% of MPOs reported using GIS.
  - there were an average of 2.4 GIS users at each MPO using GIS.
  - the average year of GIS adoption was 1988.
- The uses of GIS in the transportation community vary widely:
  - facility management (inventories of pavement, road signs, etc.)
  - planning (demographic and economic analysis)
  - network analysis (model building and analysis)
- The DOT has initiated several large-scale GIS projects.

GIS CAPABILITIES

- *Cartographic:* GIS allows maps to be displayed, manipulated, and plotted.
- *Data Management:* GIS enables the efficient storage and manipulation of geographic data, both graphic and non-graphic.
- *Analytical:* GIS permits sophisticated processing and interpretation of spatial data.



GIS ADVANTAGES AND DISADVANTAGES

- Advantages
  - functionality
  - rapid application development
  - documentation, training, support
  - cost
- Disadvantages
  - dependence on specific vendor(s)
  - limited to certain hardware platforms
  - cost

BASIC GIS CONCEPTS

- GIS *data* is organized into *layers*.
- Each layer contains *objects*.
- Objects have *geography* (e.g., point, line, region, polyline, arc, etc.)
- Objects also have *attributes* (i.e., data attached to the geography).
- Examples:
  - A *road segment layer* might contain line and polyline *objects* that have the *attributes* {address range, street name, zip code} for each object.
  - A *census tract layer* might contain region *objects* that have the *attributes* {state code, county code, tract number} for each object.

- The organization of most GISs is very similar to that of a relational database (i.e., layer ≡ relation, object ≡ tuple, attribute ≡ attribute, etc.).

COMMON GIS FUNCTIONS

- Note that many GIS products now use geographic extensions of SQL (Structured Query Language) for manipulating data.

- *Computational Queries:* aggregation and computation based on object geography and attributes.

```
Select Sum(Length(ROAD.Object)) From ROAD Group By ROAD.Classification
Select ROAD.Object From ROAD Where CentroidY(ROAD.Object) > 37
```

- *Spatial Queries:* correlation of objects in different layers based on object geography.

```
Select ROAD.Object From ROAD, COUNTY Where COUNTY.Object Contains
    ROAD.Object And COUNTY.Name = “Santa Fe”
```

- *Nonspatial Correlations:* correlation of objects in different layers based on object attributes.

```
Select ROAD.Object From ROAD, FREEWAY Where FREEWAY.Onramp = ROAD.Name
```

COMMON GIS FUNCTIONS (continued)

- *Geographic Manipulation:* creation, combining, and splitting of geographic objects.

```
Select CTBNAL, CTBNAR From TIGER Where TIGER.CTBNAL <> TIGER.CTBNAR Into
      Table TEMP1
Create Table TEMP2 (CTBNA Decimal(6,0))
Create Object As Union From TEMP1 Into Table TEMP2 Group By TEMP1.CTBNAL Data
      TEMP2.CTBNA = TEMP1.CTBNAL
Create Object As Union From TEMP1 Into Table TEMP2 Group By TEMP1.CTBNAR Data
      TEMP2.CTBNA = TEMP1.CTBNAR
Create Table TRACT (CTBNA Decimal(6,0))
Create Object As Union From TEMP2 Into Table TRACT Group By TEMP2.CTBNA Data
      TRACT.CTBNA = TEMP2.CTBNA
Drop Table TEMP1
Drop Table TEMP2
Update TRACT Set TRACT.Object = ConvertToRegion(TRACT.Object)
```

COMMON GIS FUNCTIONS (continued)

- *Thematic Mapping:* shading (or otherwise distinguishing) a map according to a particular theme.

  Shade With COUNTY.Population Ranges Apply Color Style . . .

- *Graphing:* displaying two- or three-dimensional plots based on object geography and attributes.

  Graph QUERY.County, QUERY.RoadMiles From QUERY

- *Geocoding:* assigning coordinates to data records.

- *Redistricting:* grouping map objects into districts in order to perform aggregate calculations on the data to provide totals of net values for the districts.

COMMON GIS FUNCTIONS (continued)

- *Aggregation/Disaggregation:* proportioning of attribute data when geographic objects are split or combined.
- *Digitizing:* converting paper maps to GIS digitial format.
- *Raster Image Processing:* converting aerial photographs or other images into map layers.

GIS CUSTOMIZATION AND INTEROPERABILITY

- Most GIS products have their own extensive programming languages that allow an application developer to write functions, macros and scripts for performing complex or specialized tasks.

- Most GIS products allow developers to create their own graphical user interface (GUI) for each application. This capability can be used to customize the look of a GIS and specialize the interface for specific types of analyses.

- Most GIS products can interface to external databases, system functions, and application programs, allowing the GIS to make use of specialized products where necessary.

- The fact that GISs are customizable and interoperable means that any limitations they have due to their generality can be overcome by interfacing them to other products.

POSSIBLE GIS USE IN TRANSIMS

- There is a spectrum of possible uses of GIS in TRANSIMS.
  - Preprocessing road network data obtained from MPOs and other sources.
  - Preparing plotted output from simulation runs.
  - Setting up scenarios.
  - Analyzing results.
- The scope of the applicability of GIS for TRANSIMS cannot be known until the detailed TRANSIMS requirements are available.
- Thus, GIS role in TRANSIMS could be limited to just performing data translation, or be as broad as forming the central framework for the user interfaces.